THE WEATHER AND CIRCULATION OF JULY 1966

A Month With An Extensive Heat Wave

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1. HIGHLIGHTS

One of the predominant features of the weather during July was an extended heat wave that began in the northern Mississippi Valley and the Northeast during June [1]. In July the hot weather gradually intensified as it spread southward and southwestward. Reports from 42 major Weather Bureau stations from the Rocky Mountains to the Atlantic Coast indicated record high temperatures during the month. Many of these localities reported the largest number of days with maximum temperatures above either 90° F. or 100° F. ever experienced there. Tables 1 and 2 list some of the details. The peak of the heat wave occurred from the 10th through the 16th when an average of about 397,000 square miles in the eastern two-thirds of the Nation had temperatures that exceeded 100° F. On the 11th approximately 527,000 square miles of the country had temperatures above the 100° mark.

TABLE 1.—*Record high temperatures established or equaled during July 1966*

City	Temperature (° F.)	Date	Type of Record
Hartford, Conn	102	3	All time maximum.
Concord, N.H	*102	3	Do.
LaGuardia Field, N.Y	107	3	Do.
Allentown, Pa	105	3	Do.
Harrisburg, Pa	107	3	Do.
Huron, S. Dak	112	10	Do.
Philadelphia, Pa	*104	3	July Maximum.
Reading, Pa	*103	3	Do.
Little Rock, Ark	*103	10	Daily maximum.
	*103	14	Do.
Wilmington, Del	102	3	Do.
	102	4	Do.
Rome, Ga	97	9	Do.
	100	12	Do.
	101	13	Do.
Lansing, Mich	99	3	Do.
Valentine, Nebr	108	10	Do.
Newark, N.J	105	3	Do.
Central Park, N.Y	103	3	Do.
	101	13	Do.
Harrisburg, Pa	104	4	Do.
Elkins, W. Va	*93	2	Do.
Casper, Wyo	98	7	Do.
	99	16	Do.
	99	30	Do.
Sheridan, Wyo	103	16	Do.
	100	30	Do.
Pueblo, Colo	102	5	Do.
	101	17	Do.

*Equaled previous record.

July was also marked by intensifying drought in the Northeast. Figure 1 illustrates how drought conditions varied from the beginning to the end of July in the Northeast and adjacent areas. In the Ohio Valley some sections, such as east-central Indiana, had increasing drought conditions, while in Ohio a large area shifted from mild drought to adequate moisture or even slightly wet conditions. The severest drought developed in the Washington, D.C. area and immediately northward through Maryland into Pennsylvania. Both the heat and the lack of rainfall contributed to the critical condition. Washington D.C. had only 0.93 in. of a normal 4.15 in. of rain during July, while Harrisburg, Pa. had only 0.81 inches of a usual 3.51 in. During May, June, and July, Harrisburg received only 1.86 in., their lowest precipitation for any consecutive three months of record. Some areas in the Northeast did receive at least temporary drought relief during the month. Albany, N.Y., received 3.88 in. of rainfall which was slightly more than the July normal and was the heaviest July amount since 1961. Buffalo, N.Y. reported 4.92 in. which was 2.35 in. above normal.

Drier than normal weather in parts of the Great Plains, Rocky Mountain States, and some areas west of the Rockies also persisted. Flagstaff, Ariz., Mount Shasta, Calif., Casper and Sheridan, Wyo., and Reno, Nev., all reported six or more consecutive months with below normal precipitation. At Wendover, Utah, general showers on the last day of the month broke a prolonged dry spell. Concordia, Kans. reported another month with deficient rainfall which contributed to the less than half of normal precipitation there so far in 1966. Kansas City, Mo. reported the driest July of record.

TABLE 2.—*Duration of heat wave in July 1966*

City	Temperature (° F.) equaled or exceeded	Number of Days
Hartford, Conn	90	16
Washington, D.C	90	20
Central Park, N.Y	90	9
Greensboro, N.C	90	20
Oklahoma City, Okla	100	21
Philadelphia, Pa	100	3
Cheyenne, Wyo	90	18
Memphis, Tenn	100	6

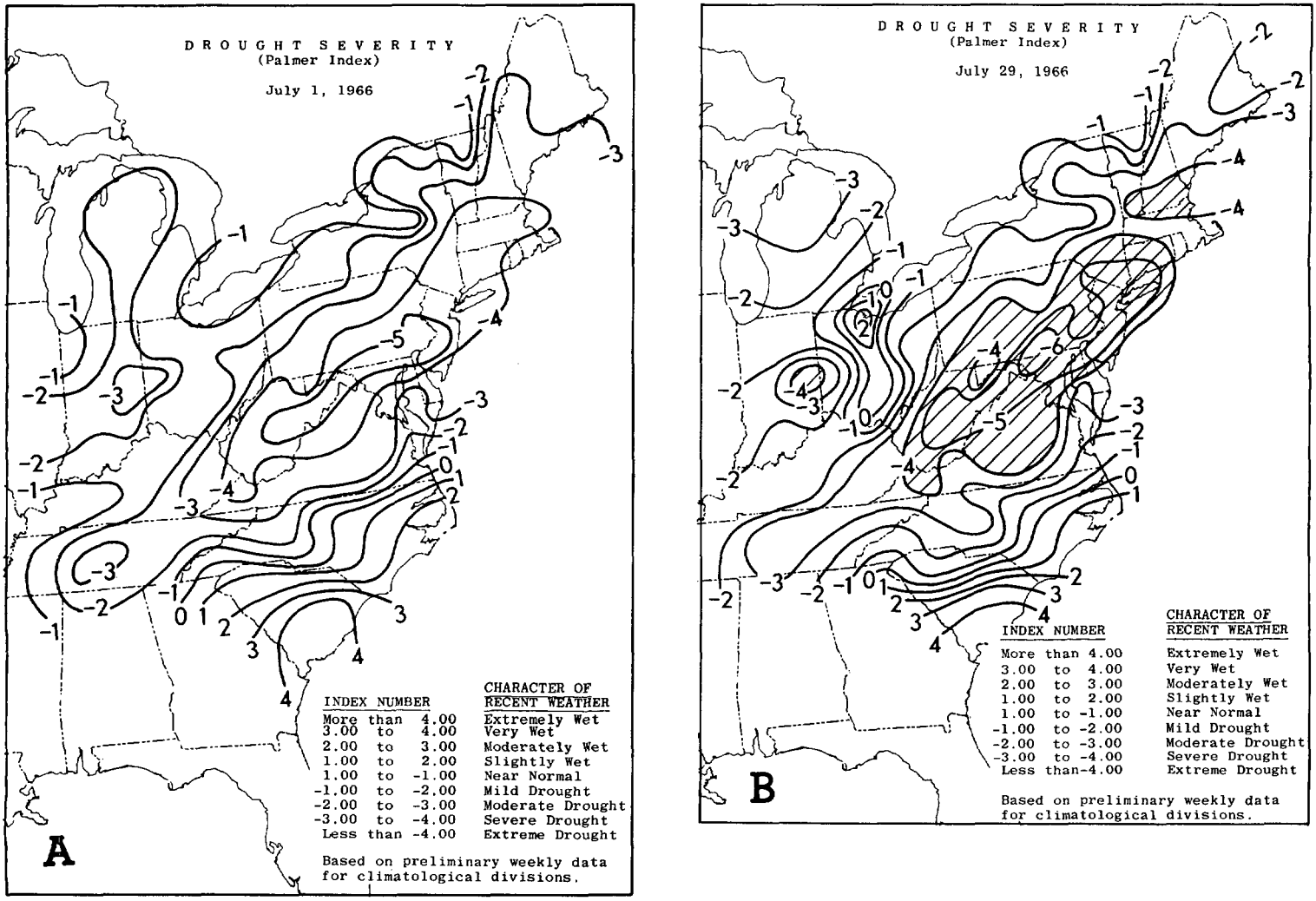


FIGURE 1.—Palmer drought index for eastern United States (A) July 1, 1966, (B) July 29, 1966 (from [4]).

2. MEAN CIRCULATION

Over the western half of the Northern Hemisphere the 700-mb. flow in July was much more meridional than normal (figs. 2 and 3). A ridge over North America with a trough along each coast is the usual July pattern, but this year (fig. 2) (as in other summer drought years) the ridge over the United States was displaced eastward from its normal Rocky Mountain location, resulting in a positive anomaly somewhere over the eastern two-thirds of the country.

The Atlantic anticyclone was more than 10° north of its normal July position and unusually strong. Anomalously strong northerly flow east of this intense anticyclone and the resulting deep trough downstream gave unusually cool weather to much of Europe. Figure 5 shows that to the east of the deep European trough the main polar westerlies were again deflected north of their usual July position. However, over Asia and most of the Pacific the major westerlies were slightly south of their normal position. Wind speeds over the western half of the Pacific were considerably stronger than normal, as evidenced by the anomalous flow along the 40th parallel in that area (fig. 3).

The basic pattern over the eastern Pacific, across North America, and over the Atlantic was similar to the three-season average circulation for the 1952–54 summers (fig. 4) that Namias [2] related to drought. Compare the location of the three major positive anomaly centers over the eastern Pacific, North America, and the Atlantic in figures 3 and 4. Namias demonstrated in an earlier article [3] that the presence of two of these positive centers implies the third.

3. TEMPERATURE

Most of the Nation from the Rocky Mountains eastward had temperatures considerably above normal for July (fig. 6). This extensive area of warmth is consistent with the ridge over the Midwest and the associated area of positive height anomaly centered over the Northern Plains (figs. 2 and 3). The temperature anomaly for the

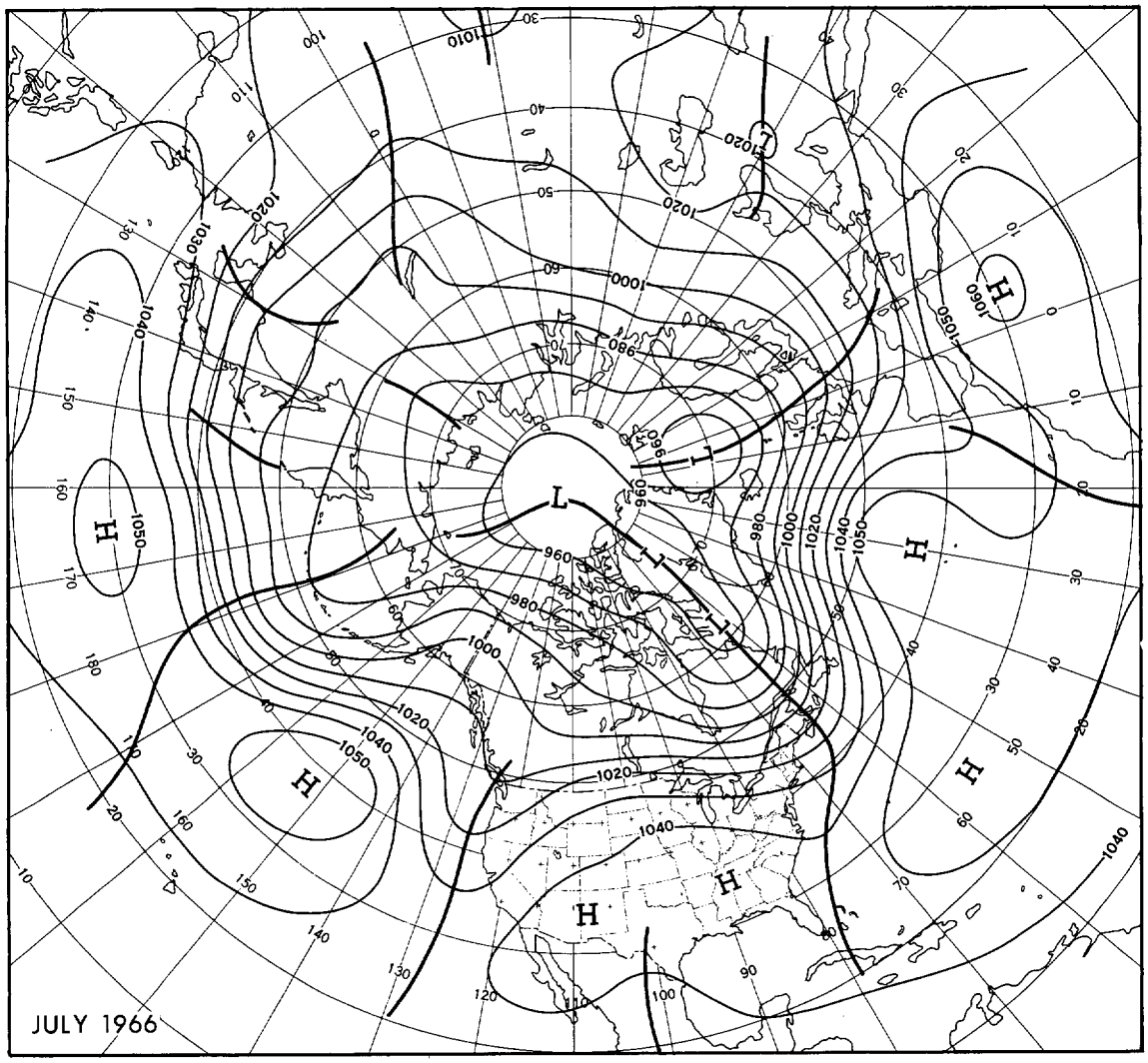


FIGURE 2.—Mean 700-mb. contours (tens of feet), July 1966. A typical heat wave and drought pattern.

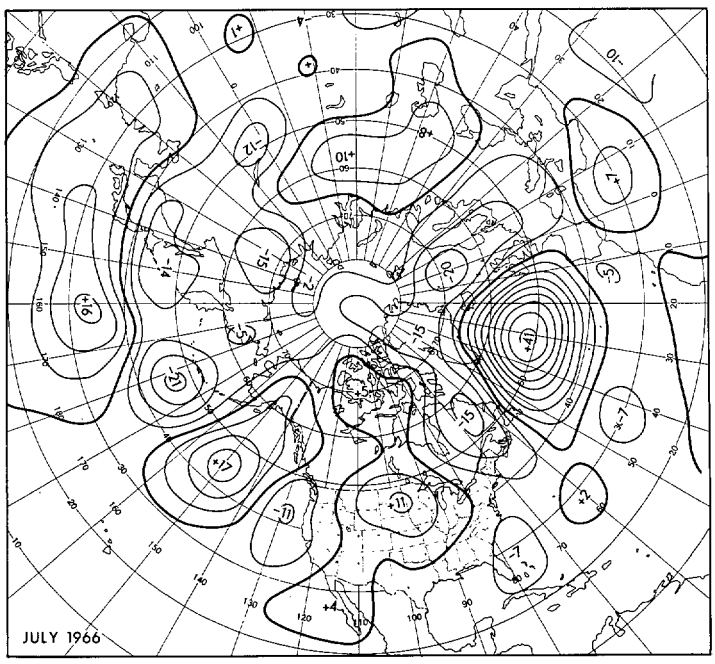


FIGURE 3.—Departure of mean 700-mb. heights from normal (tens of feet), July 1966. The strong positive anomaly in the Atlantic was the most intense anomaly in the hemisphere.

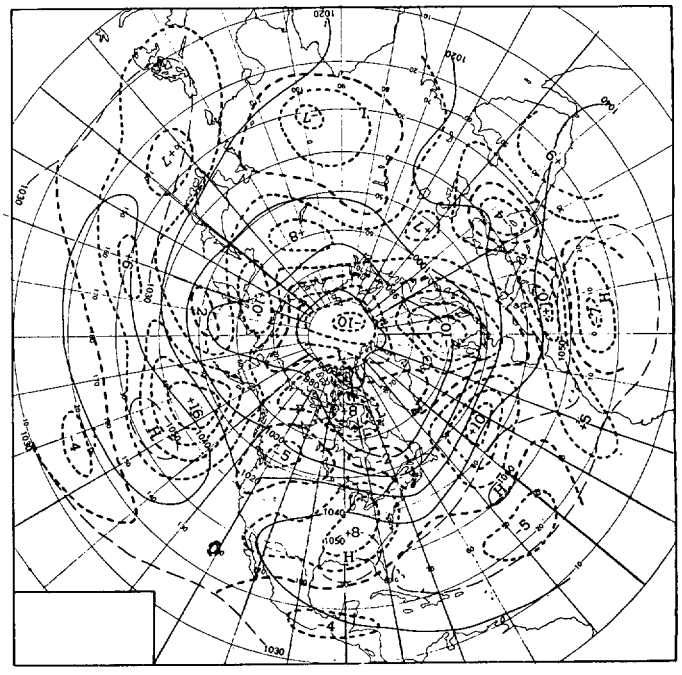


FIGURE 4.—Mean 700-mb. contours (solid) and departure of 700-mb. heights from normal (dashed) (both in tens of feet). for three summers 1952–54 (from [2]).

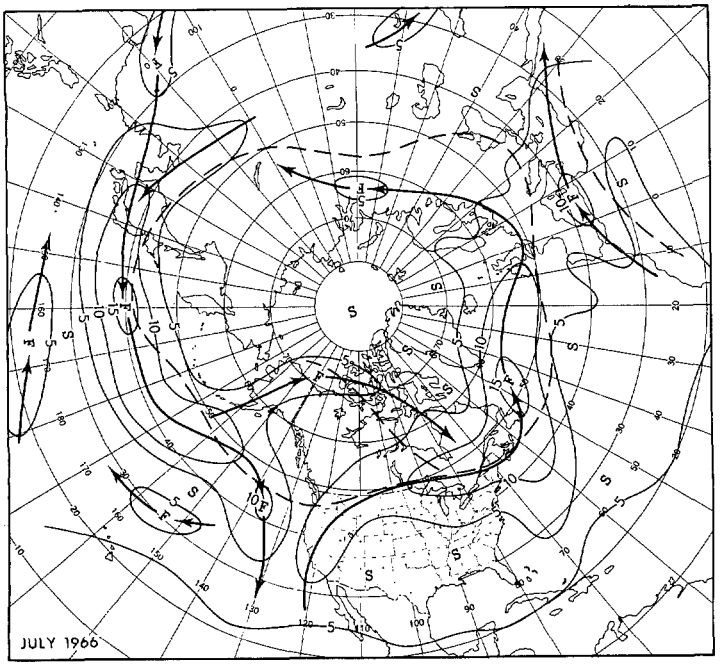


FIGURE 5.—Mean 700-mb. isotachs (meters per second), July 1966. Solid arrows indicate principal axes of maximum wind speed and dashed lines the normal.

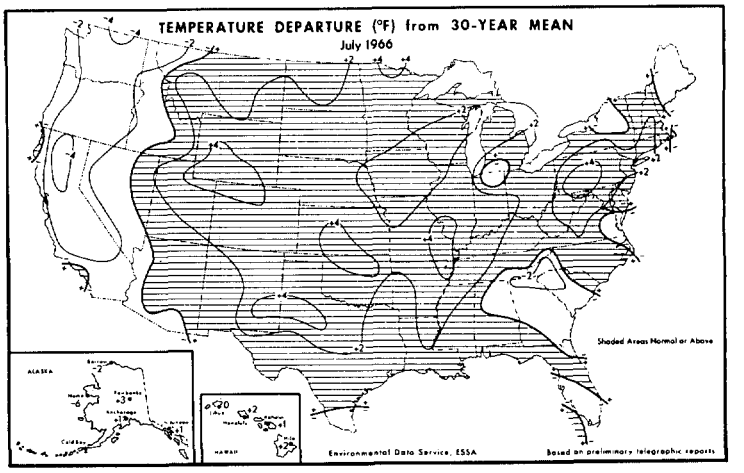


FIGURE 6.—Surface temperature departure from normal (°F.), July 1966 (from [4]).

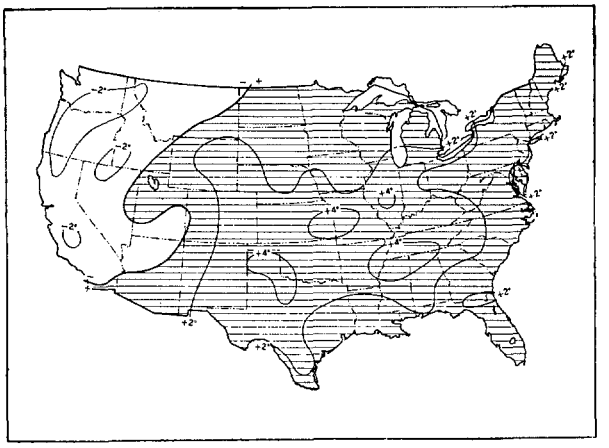


FIGURE 7.—Average temperature departures from normal (°F.) for three summers (June, July, and August) of 1952–54 (from [2]).

drought summers 1952–54 mentioned earlier (fig. 7) was extremely similar to the pattern of this July. Below normal temperatures in the Southeast were associated with the below normal 700-mb. heights in that section. In the Far West a deep trough along the coast (fig. 2) allowed frequent incursions of cool maritime air that resulted in below normal temperatures west of the Rockies.

4. PRECIPITATION

This July there were some very great contrasts in the precipitation amounts at nearby stations. Raleigh, N.C., had only 0.91 in. of rain for the driest July since 1953, but Wilmington, N.C., reported 15.12 in., the largest July total in 96 years of record. Omaha, Nebr., received 4.70 in., while only 0.89 in. fell at Kansas City, Mo. just to the south. Oak Ridge, Tenn., had less than half its normal rainfall, but nearby Knoxville received 5.44 in., which was more than normal. Charleston, W. Va. had a deficiency of 2.73 in.; Huntington, W. Va., had an excess of 1.87 in.

The unusually heavy band of precipitation from northern California across Oregon and Washington was the result of the deep trough along the coast. Several stations in that area received record amounts of rain for July. Walla Walla, Wash. received 1.78 in. which was 1.57 in. above the normal and the largest July amount since 1873. Sacramento, Calif. had its largest July rainfall since 1881, although the total amount was only 0.09 in. Medford, Oreg., with 1 63 in. (1.42 in. above normal), also reported the wettest July of record. However, even with these anomalously large July rainfall totals many parts of Oregon and nearby areas were still unusually dry. At Pendleton, Oreg., where 0.79 in. fell (0.57 in. above normal), the April through July rainfall was the lowest of record.

Again a comparison can be made with one of the drought patterns presented in [2]. Note the strong similarity between the precipitation patterns of July 1957 and July 1966 (figs. 8 and 9). Since isentropic charts are no longer routinely prepared by any section of the National Meteorological Center, no attempt was made to produce a mean monthly isentropic chart for this July as Namias did for July 1957 [2]. Namias used the isentropic chart to demonstrate that large quasi-stationary drought-producing anticyclones are generally composed of "two spirally inflowing currents—one moist stream flowing northward on its western periphery before recurving eastward and often southward; the other, a dry stream cast off from the northern westerlies and sinking to lower elevations as it

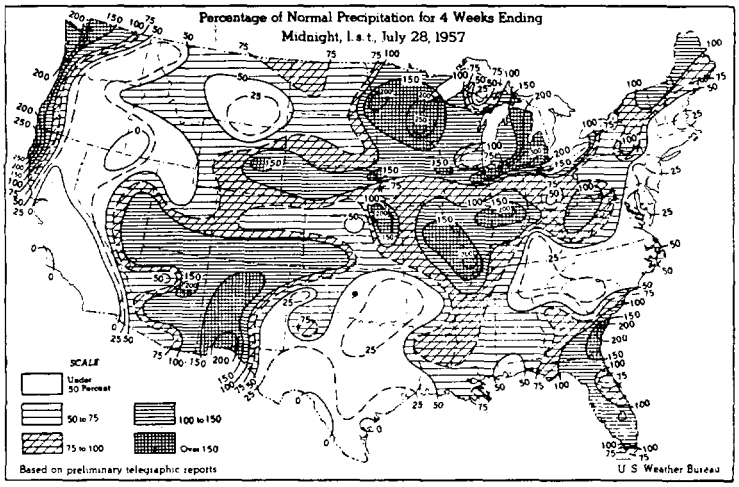


FIGURE 8.—Percentage of normal precipitation for July 1 to 28, 1957 (from [2]).

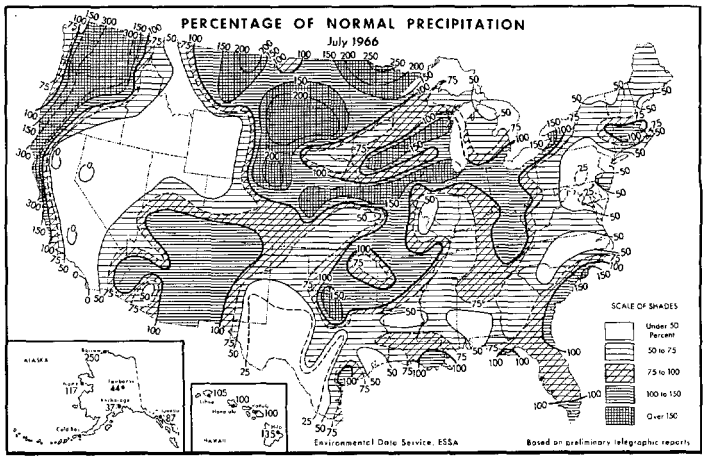


FIGURE 9.—Percentage of normal precipitation, July 1966 (from [4]).

spirals anticyclonically into the core of the anticyclone. This asymmetry in moisture and usually vertical stability leads to a substantial difference in precipitation underneath the moist and dry branches—variations which appear to be related to the enhancement or inhibition of penetrative convection by entrainment of moist or dry air, respectively, into rising air columns." In both July 1957 and this July there were three major areas of unusual dryness: one extending northward from southern California over the Great Basin to the vicinity of western Montana, a second in the Texas region, and a third that encompassed much of the Middle Atlantic States and the Northeast.

5. VARIABILITY WITHIN THE MONTH

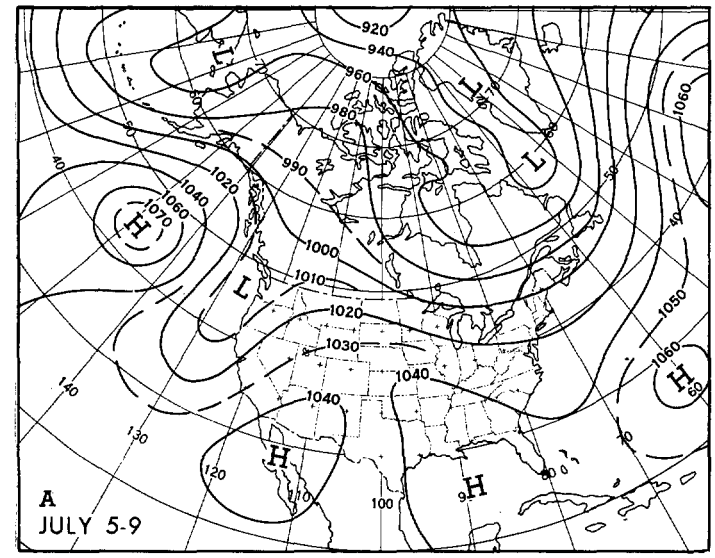
The extreme heat wave in the Northeast reached a peak about July 3, when temperatures up to 107° F. were reported (table 1). Then, as the upper-level ridge moved westward, and the center of the 700-mb. High (fig. 10A) moved southward from its position over the Ohio Valley at the beginning of the month [1], the greatest positive temperature anomaly appeared over the Central Plains (fig. 10B). However, the Northeast continued quite warm with temperatures still ranging 3° to 6° above normal from southern New England and New York State southward over most of the Middle Atlantic States. East of the Rockies only southern Florida, southern Texas, and a small section of the southern Appalachians had below normal temperatures. In the Far West below normal temperatures were in response to the deep trough along the west coast.

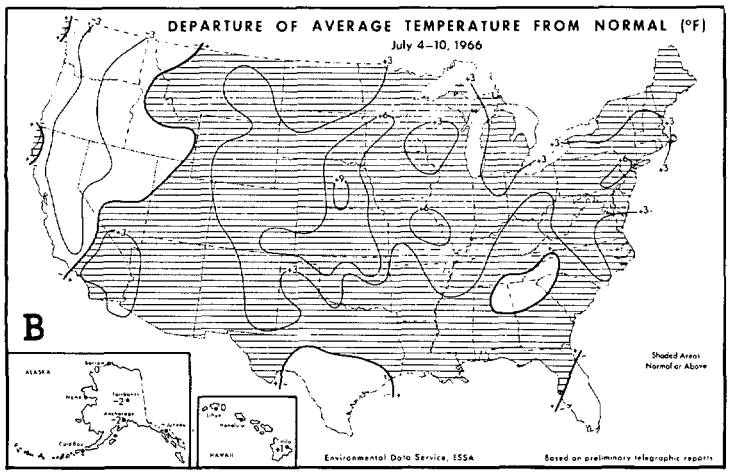
Precipitation was generally quite light (fig. 10C) over the country during this period because of the presence of the large ridge over the Midwest (fig. 10A). Air mass thundershowers in the southerly current west of the 700-mb. anticyclone centered over the Gulf of Mexico accounted for the heavy precipitation in Texas and the southern part of the other Gulf States. Heavy precipitation in the Ohio and northern Mississippi Valleys was the result of frontal showers and thunderstorms along the leading edge of the air mass that brought the moderating temperatures to the Northeast.

As mid-month approached, the northern part of the ridge that had been over the Gulf of Alaska sheared and moved into northwestern Canada (fig. 11A). This ridge merged with the relatively stationary ridge over the United States, causing an amplification of the continental ridge and a deepening of the trough along the east coast of North America. The resulting increased northwesterly flow brought additional cooling to the Northeast (fig. 11B). Maine registered temperatures that averaged several degrees below normal and slightly below normal temperatures were recorded for much of Michigan during the week. However, under the center of the very strong ridge aloft, the heat wave over the Plains and most of the Mississippi Valley persisted and spread northward and slightly westward. The trough off the west coast moved closer to the coast with resulting increased cloudiness and cooling, especially in the Central Valley of California, where temperatures averaged 6° to 9° below normal in most areas.

For the week of July 11–17 heavier precipitation was more widespread than during the previous week (fig. 11C). The cold front associated with cooling in the Northeast pushed all the way into the Southeast, and frontal showers and thunderstorms accounted for most of the heavy precipitation this week.

Large-scale retrogression of most of the major features of the upper-level circulation over North America and the adjacent Oceans (fig. 12A) during the week of July 18–24 broke the intense heat wave and brought cooling to most of the eastern two-thirds of the country (fig. 12B). The deep upper-level Low that had been centered along the coast of Labrador moved westward to central Quebec,





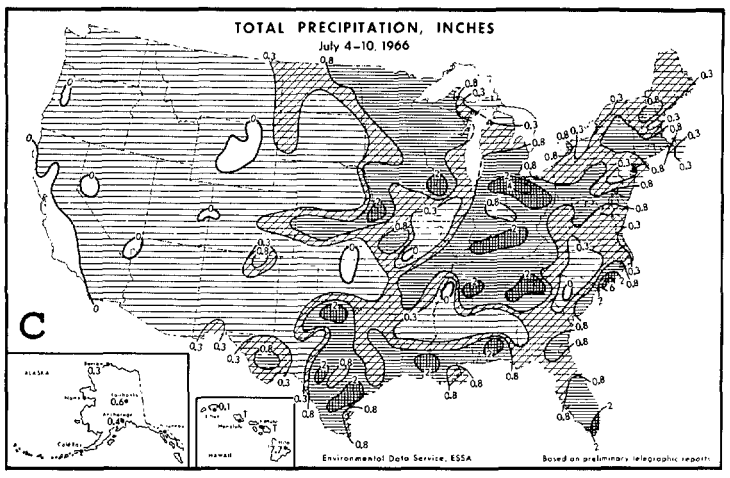
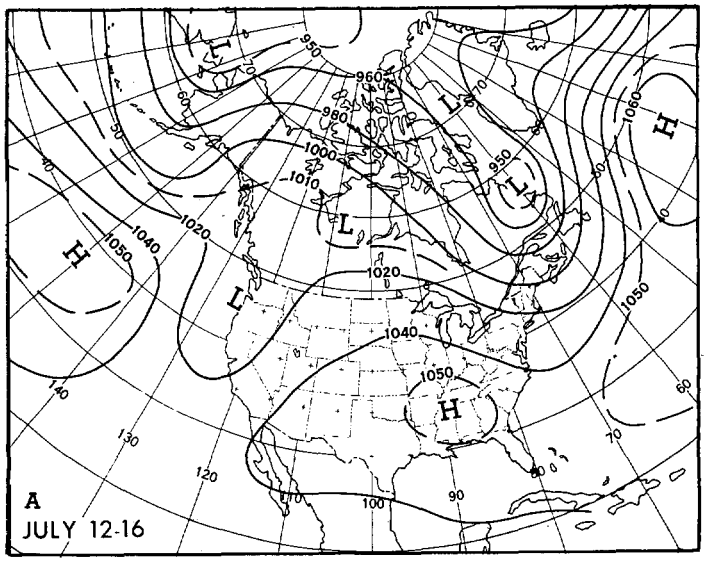
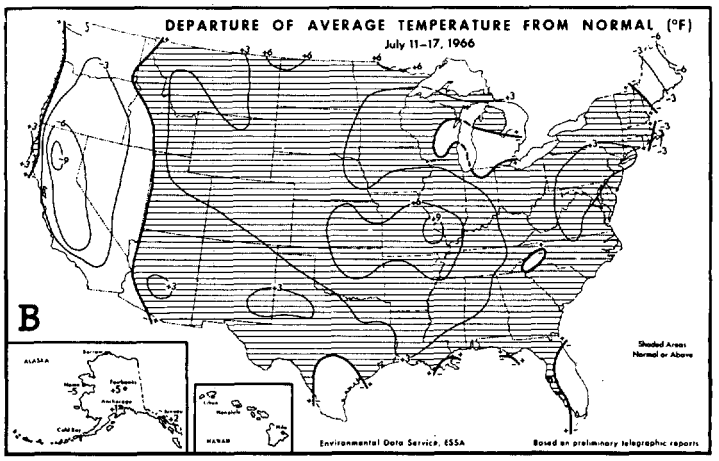


FIGURE 10.—Week of July 4–10, 1966: (A) 700-mb. contours (tens of feet), July 5–9; (B) surface temperature departure from normal (°F.); (C) total precipitation (in.); (B) and (C) from [4].





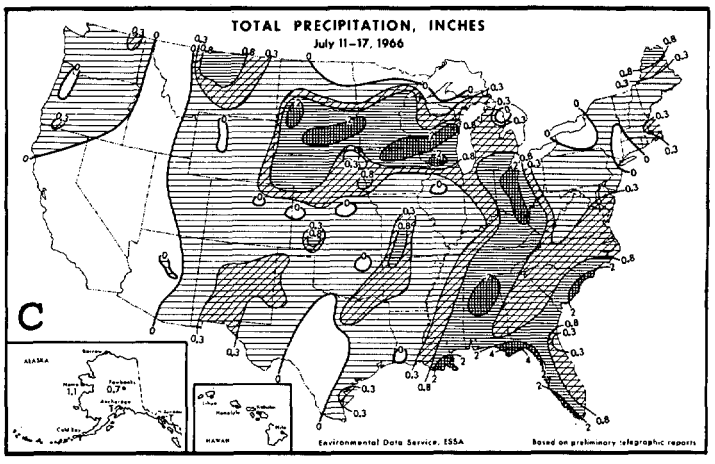
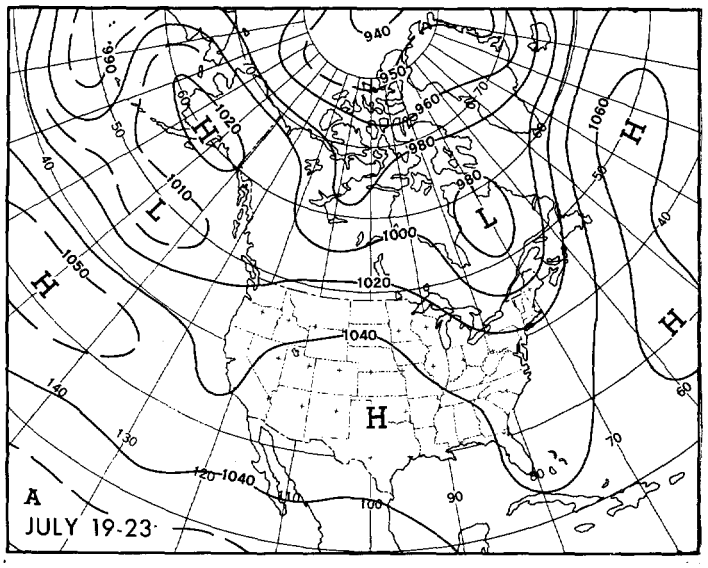
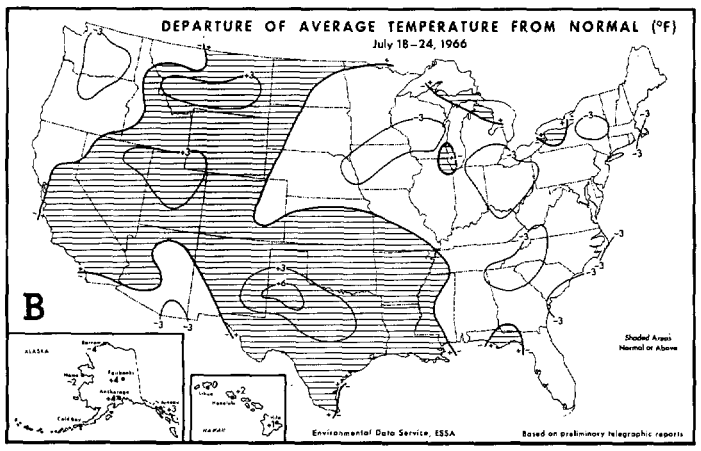


FIGURE 11.—Week of July 11–17, 1966: (A) 700-mb. contours (tens of feet), July 12–16, 1966; (B) and (C) as in figure 10.

and the High centered over northern Mississippi the previous week shifted to Texas. Discontinuous retrogression occurred off the west coast with a new trough forming about 20° farther west, while the coastal trough moved northeastward into central Canada. This allowed major warming in California's Central Valley for the first time in several weeks. Temperatures also rose over the Great Basin. The warmest weather this week, except for the southwestern desert area and the Central Valley, was in Texas under the upper-level High.





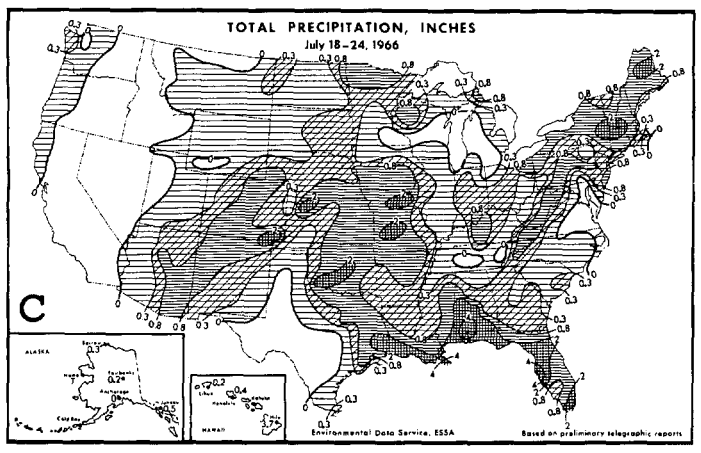
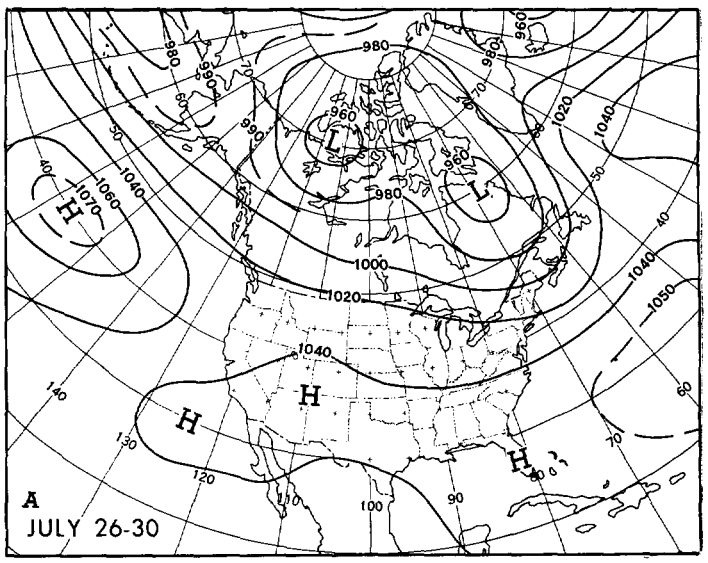
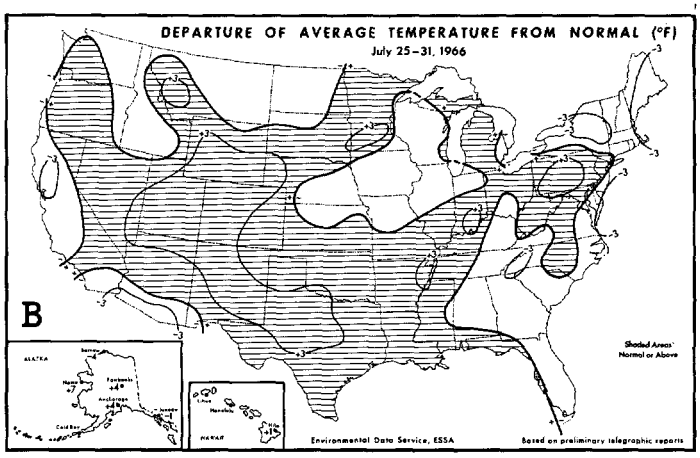


FIGURE 12.—Week of July 18–24, 1966: (A) 700-mb. contours (tens of feet), July 19–23; (B) and (C) as in figure 10.





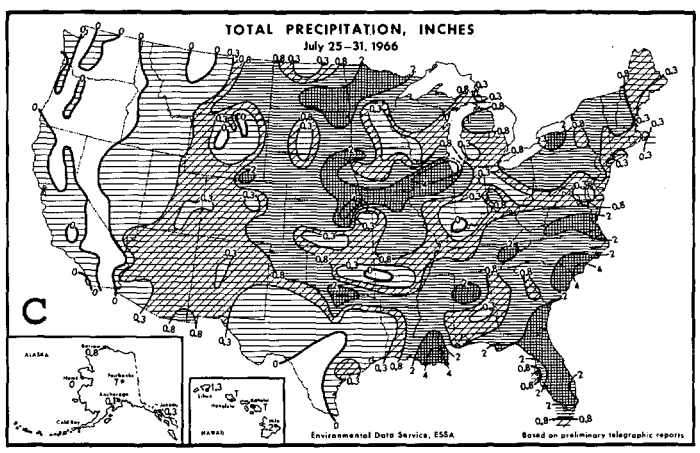


FIGURE 13.—Week of July 25–31, 1966: (A) 700-mb. contours (tens of feet), July 26–30; (B) and (C) as in figure 10.

Most of the heavy precipitation during the week of July 18–24 (fig. 12C) again occurred along fronts. An intensifying and slow moving surface anticyclone passing near the Great Lakes spread cool air southward to the Gulf Coast and southern Florida, and westward to the Rocky Mountains in the Colorado area. Numerous showers and thunderstorms along this front gave a temporary break in the critical drought in parts of the Northeast and brought much needed moisture to crops that had been parched by the searing heat in the Central Mississippi Valley and much of the Plains.

Further retrogression of the long-wave ridge over the United States during the final week of July (fig. 13A) slightly decreased the intensity of the heat in portions of Texas but temperatures still remained above normal in that area. Over other areas east of the Rockies the decreased strength of the northerly anomalous flow allowed a warming trend (fig. 13B). The return of the very weak mean trough to the west coast again brought some cloudiness and below normal temperatures to much of California.

The front that brought relief from the heat wave the previous week slowly dissipated in the Southeast early in the last week of July; however it contributed to the heavy precipitation in that section (fig. 13C). As the week progressed, the polar front reformed near the northern border of the United States; then, as this front slowly progressed southward, frontal waves caused scattered areas of quite heavy rainfall throughout the Nation east of the Rockies. By the end of the month this front had also moved into the Southeast, causing very heavy rain near Wilmington, N.C. The 4-in. rainfall in southeastern Louisiana was caused by a weak depression that formed over the northern Gulf of Mexico and moved inland before filling.

6. TROPICAL STORMS

There were four tropical storms in the Atlantic during July. The first of these, Becky, formed northeast of Bermuda on the 2d and became lost in the westerlies within 24 hr. without attaining hurricane strength. Celia formed northeast of Puerto Rico on the 13th and moved west-northwestward, reaching hurricane strength briefly before dissipating on the 15th. Celia did not move beyond 25° N., 70° W. as an identifiable storm. Dorothy was the most intense and long lasting of the July storms. It formed in the central Atlantic near 30° N., 40° W. on the 23d and moved slowly northwestward, then northeastward, remaining east of the 45th meridian. This storm was still moving slowly northeastward at the end of the month in the central Atlantic but soon lost its identity in the westerlies. Ella, the last of the Atlantic storms this month, formed in the same general area as did Celia, but a few degrees farther east. Ella traveled about the same course as Celia but never attained hurricane strength before dissipating on the 28th between 65° and 70° W.

There were also four tropical disturbances in the western Pacific but none in the eastern Pacific during July. Two of these storms reached typhoon strength. Tropical storm Lola and Typhoon Ora formed in the South China Sea and moved northward into China before dissipating. Typhoon Mamie and tropical storm Nina formed near 20° N., 130° E. and moved west-northwestward toward the China coast. One of these storms dissipated in the China Sea and the other over land. Of the storms that entered China all crossed the coast between Canton and the Liuchow Peninsula.

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